HP Smart Array 6402 Controller for Integrity Servers User Guide

March 2004 (First Edition)
Part Number 365510-001

© 2004 Hewlett-Packard Development Company, L.P.

Microsoft®, Windows®, and Windows NT® are U.S. registered trademarks of Microsoft Corporation.

Hewlett-Packard Company shall not be liable for technical or editorial errors or omissions contained herein. The information in this document is provided “as is” without warranty of any kind and is subject to change without notice. The warranties for HP products are set forth in the express limited warranty statements accompanying such products. Nothing herein should be construed as constituting an additional warranty.

March 2004 (First Edition)

Part Number 365510-001

Audience Assumptions

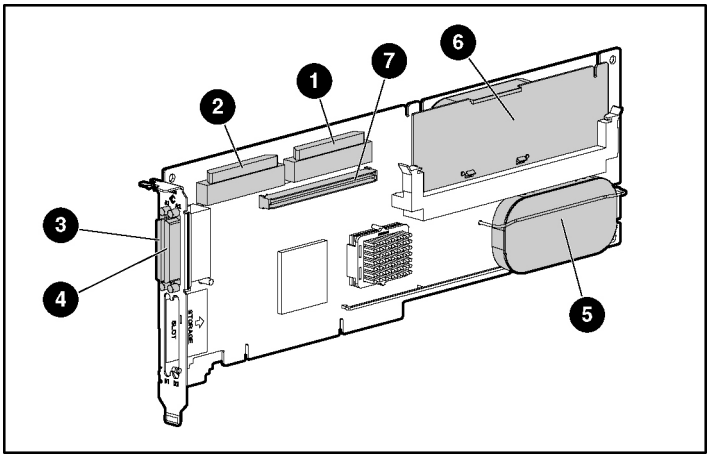
This document is for the person who installs, administers, and troubleshoots servers and storage systems. HP assumes you are qualified in the servicing of computer equipment and trained in recognizing hazards in products with hazardous energy levels.

Contents

Hardware Features

In This Section

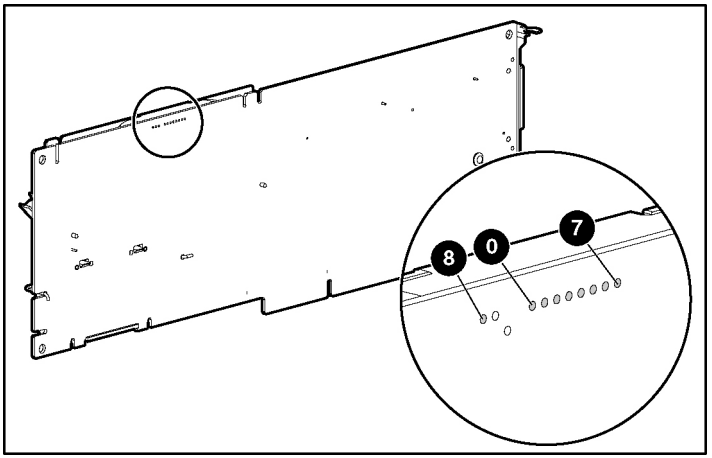
Board Components



Item ID	Description
1	Internal SCSI connector, port A1 (do not use simultaneously with item 3)
2	Internal SCSI connector, port A2 (do not use simultaneously with item 4)
3	External SCSI connector, port A1 (do not use simultaneously with item 1)
4	External SCSI connector, port A2 (do not use simultaneously with item 2)
5	Controller battery
6	Battery-backed cache module

Item ID	Description
7	Connector for expansion board

Controller Board Runtime LEDs

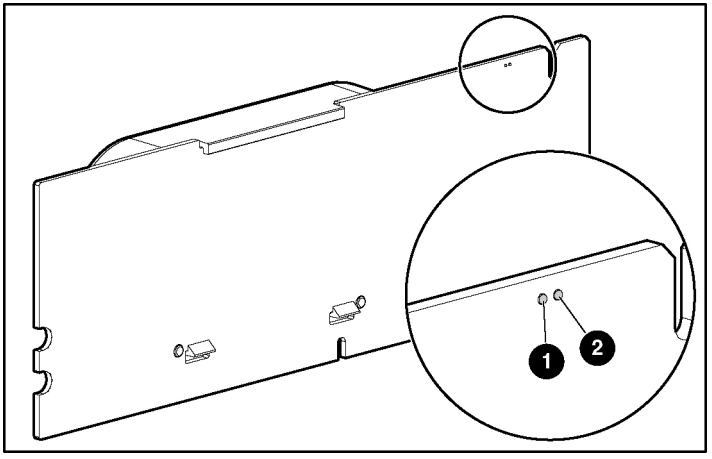


NOTE: During server power up, each runtime LED illuminates randomly until POST has finished.

LED ID	Color	LED Name and Interpretation
0	Amber	CR100: Diagnostics Error LED.
1	Amber	CR101: Drive Failure LED. A physical drive connected to the controller has failed.
2	Blue	CR102: SCSI Bus Active LED. At least one of the SCSI buses on the controller is active.
3	Green	CR103: XOR Active LED. The controller is calculating parity data.
4	Green	CR104: Command Outstanding LED. The controller is working on a command.
5	Blue	CR105: Heartbeat LED. This LED flashes every 2.0 seconds, unless the controller is malfunctioning.
6	Green	CR106: Gas Pedal LED. This LED illuminates when the controller gets very busy.
7	Green	CR107: Idle Task LED. Under normal circumstances, this LED flashes every 1.0 seconds. When the controller is busy, the LED glows steadily.

LED ID	Color	LED Name and Interpretation
8	Amber	CR11: Status Charging LED. The controller battery is being charged.

Cache Module LEDs



Item ID 1 Green LED	Item ID 2 Amber LED	Interpretation
Steady glow	--	The cache batteries are being charged.
Fast blink	--	The cache microcontroller is waiting for the host controller to communicate.
--	Steady glow	One of these conditions is present: • There is a short circuit across the battery terminals or within the battery pack. • The host controller is updating the cache microcontroller firmware.
--	Fast blink	There is an open circuit across the battery terminals or within the battery pack.
--	Slow blink (once every 16 seconds)	This display pattern may occur after the system is powered down. It indicates that the cache contains data that has not yet been written to the drives. Restore system power within four days to prevent data loss.

Controller Specifications

Dimensions (excluding bracket)	31.2 cm x 10.7 cm x 1.8 cm (12.3 in x 4.2 in x 0.7 in)
Power required	Less than 17 W
Ambient room temperature range	Operating: 10° to 35°C (50° to 95°F) Storage: -20° to 55°C (-4° to 131°F)
Relative humidity (noncondensing)	Operating: 10% to 70% Storage: 5% to 90%
RAID levels supported	0, 1+0, 5, ADG
Processor type	PowerPC 405 at 266 MHz
DDR SDRAM bus transfer rate	Up to 2.0 GB/s at 266 MHz (DDR, 72-bit)
Connector required on system board	3.3-V, 64-bit, Wide PCI-X or PCI slot
PCI-X transfer rate	Up to 1.0 GB/s at 133 MHz (64-bit)
Number of SCSI channels	2 LVD-only
Maximum number of drives per channel	15 (14 in an external enclosure)
SCSI connector type	68-pin Wide internal, VHDCI external
SCSI termination	Required, but provided on Compaq and newer HP systems
SCSI transfer rate	Up to 320 MB/s (160 MHz DDR) per channel

For more information about the controller features and specifications and for information about system requirements, refer to the HP website (http://www.hp.com/products/smartarray).

Overview of the Installation Procedure

In This Section

Installation in an Integrity Server Using Microsoft Windows

The following steps summarize the procedure for installing the controller in an Integrity server running Microsoft® Windows® and configuring the controller as the boot controller.

1. Install the controller hardware ("Installing the Controller Hardware" on page 13).
2. Update the controller firmware ("Updating the Firmware" on page 19).
3. Configure the logical boot drive, using ORCA ("Configuring an Array" on page 21).
4. If performing a manual installation, load the OEM boot driver ("Loading the OEM Boot Driver" on page 27).
5. Install the operating system.
6. If you are installing additional Smart Array controllers, install the latest device drivers for each controller ("Installing Drivers for Additional Controllers" on page 27).
7. Install ACU from the Smart Setup CD or DVD.
8. Install the Management Agents ("Installing the Management Agents" on page 29).
9. Create and format additional logical drives if desired, using ACU ("Configuring an Array" on page 21).

The server is now ready to use.

Installing the Controller Hardware

In This Section

Before Beginning the Installation

Before beginning the installation procedure, visit the HP website (http://www.hp.com/support) to confirm that you have the latest version of each driver and utility file needed. Compare the version numbers of the files there with those of the same files on the software CD or DVD that is supplied in the controller kit.

Preparing the Server

Before installing the controller in the server, back up all data. This step is **required** if you are moving non-arrayed SCSI drives to a Smart Array controller, because data is not preserved during a move between array controllers and non-array controllers.

If the server supports hot-pluggable devices, you can install the controller board without any further preparation ("Installing the Controller Board" on page 14).

To prepare a server that does not support hot-pluggable devices:

1. Close all applications.
2. Power down the server.

CAUTION: In systems that use external data storage, be sure that the server is the first unit to be powered down and the last to be powered back up. Taking this precaution ensures that the system does not erroneously mark the drives as failed when the server is powered up.

3. Power down all peripheral devices that are attached to the server.
4. Unplug the AC power cord from the outlet and then from the server.
5. Disconnect all peripheral devices from the server.

Installing the Controller Board

WARNING: To reduce the risk of personal injury or damage to the equipment, consult the safety information and user documentation provided with the server before attempting the installation.

Many servers are capable of providing energy levels that are considered hazardous and are intended to be serviced only by qualified personnel who have been trained to deal with these hazards. Do not remove enclosures or attempt to bypass any interlocks that may be provided for the purpose of removing these hazardous conditions.

1. Remove or open the access panel.
2. Select an available 3.3-V PCI or PCI-X slot.

   NOTE: In Integrity servers, the ID number of the slot in which you insert the controller determines the boot controller order. Follow the recommendations in the server-specific documentation to obtain the required controller order.

3. Remove the slot cover or open the hot-plug latch. Save the retaining screw if one is present.
4. Slide the controller board along the slot alignment guide, and press the board firmly into the slot so that the contacts on the board edge are properly seated in the system board connector.
5. Secure the controller board in place with the hot-plug latch or retaining screw. If there is a guide latch on the rear of the board, close the latch.

6. To finish installing the hardware, connect the internal and external drives ("Connecting Storage Devices" on page 15).

Connecting Storage Devices

The controller supports Ultra2, Ultra160 (Ultra3), and Ultra320 drives.

Each peripheral that is connected to the controller must have a unique SCSI ID value within the range of 0 to 15 (except ID 7, which is reserved for controller use). This value determines the priority that is given to the device when it attempts to use the SCSI bus.

The system automatically sets the SCSI IDs for hot-pluggable devices if they are supported. For non-hot-pluggable devices, you must set the ID values manually by using switches or jumpers on the device itself.

SCSI buses require termination on both ends to prevent signal degradation. In HP ProLiant and Integrity servers, however, the controller, SCSI cable, and backplane already provide this termination.

Connecting Internal Storage

1. If the storage device that you are adding is not hot-pluggable, power down the system.
2. Install drives in the removable media bays on the server.

   CAUTION: Do not use hot-pluggable drives on the same SCSI bus as non-hot-pluggable drives.

   NOTE: Drives that are to be grouped in the same array should all have comparable capacity for efficient use of total storage capacity.

   For additional information about drive installation, refer to the appropriate section in this guide ("Replacing, Moving, or Adding Hard Drives" on page 37) and consult the documentation that accompanied the drives.

   When you have finished installing drives, continue with the next step.

   – If the drives are hot-pluggable, go to step 3.

– If the drives are not hot-pluggable, go to step 4.

3. Attach the internal point-to-point SCSI cable (provided with the server) from the internal connector of the controller to the hot-plug drive cage.

   Installation of the hot-pluggable drives is complete.

4. For each SCSI bus, manually set the SCSI ID on each drive to a unique value in the range of 0 to 15, except 7 (which is reserved for controller use). For detailed instructions, consult the documentation that is provided with the drive.
5. Attach a multi-device SCSI cable from the internal connector of the controller to the non-hot-pluggable hard drives. (The cable may have been provided with the server.)
6. Replace the access panel, and secure it with the thumbscrews if any are present.

CAUTION: Do not operate the server for long periods without the access panel. Operating the server without the access panel results in improper airflow and improper cooling that can lead to thermal damage.

Connecting External Storage

1. On the rear of the server, connect the external cable to the VHDCI connector on the controller, and tighten the lock screws on the cable connector.
2. Attach the other end of the cable to the storage enclosure, and tighten the lock screws on the cable connector.

SCSI Cable Part Numbers

NOTE: If you require additional cables, order them by the option kit number.

SCSI cable type	Cable Length	Option Kit Number	Cable Assembly Number
External VHDCI cables for all server models	1.8 m (6 ft) 3.7 m (12 ft) 7.3 m (24 ft) 11.9 m (39 ft)	341174-B21 341175-B21 164604-B21 150214-B21	313374-001 313374-002 313374-004 313374-005
Internal multi-device cable for ProLiant servers	varies	166389-B21	148785-001
Internal cables for rx5670 servers (kit contains one single-port cable and one dual-port cable)	Single-port: 18 cm (7 in) Dual-port: 20 cm (8 in)	A9828A	A9828-63001 (single-port) A9828-63002 (dual-port)
Internal cables for rx2600 servers (kit contains one single-port cable and one dual-port cable)	Single-port: 49 cm (19 in) Dual-port: 58 cm (23 in)	A9827A	A7231-63024 (single-port) A7231-63025 (dual-port)

Updating the Firmware

In This Section

Using the Smart Components

To update the firmware, you can use Smart Components, also known as Online ROM Flash Components ("Using the Components on the Website" on page 19). These components are available on the HP website (http://www.hp.com/support/itaniumservers). Alternatively, you can use the software CD or DVD that is provided in the controller kit ("Using the Files on the CD or DVD" on page 20).

Because the Smart Components might be more recent than the firmware upgrade files on the CD or DVD, check the Smart Components on the website before using the updates on the CD or DVD.

Using the Components on the Website

1. Visit the HP website (http://www.hp.com/support/itaniumservers).
2. Locate the Smart Components for the operating system and controller that the server is using.
3. Follow the instructions for installing the components. These instructions are given on the same Web page as the components.
4. Follow the additional instructions that describe how to use the components to flash the ROM. These instructions are provided with each component.

Using the Files on the CD or DVD

For an Integrity server using a supported Microsoft® Windows® operating system:

1. Insert the HP Smart Setup CD or DVD into the appropriate drive on the server.
2. Locate the Windows®-based configuration utility on the CD or DVD.
3. Double-click the icon for the utility. The utility opens and automatically updates the firmware.
4. Reboot the server for the firmware updates to take effect.

For more information about Integrity servers, for technical support, or for updated firmware, drivers, and utilities, refer to the HP website (http://www.hp.com/support/itaniumservers).

Configuring an Array

In This Section

Introduction

HP provides two utilities for manually configuring an array on a Smart Array controller:

- ACU—A versatile, browser-based utility that provides maximum control over configuration parameters
- ORCA—A simple ROM-based configuration utility that runs on all operating systems

NOTE: To copy a particular array configuration to several other servers on the same network, use the scripting capability of ACU.

Whichever utility you use, the following limitations apply:

- For the most efficient use of drive space, do not mix drives of different capacities within the same array. The configuration utility treats all physical drives in an array as if they have the same capacity as the smallest drive in the array. The excess capacity of any larger drives is wasted because it is unavailable for data storage.
- The probability that an array will experience a drive failure increases with the number of physical drives in the array. If you configure a logical drive with RAID 5, keep the probability of failure low by using no more than 14 physical drives in the array.

For information about default array configuration settings, refer to the *HP Array Configuration Utility User Guide.* This document is available on the Documentation CD that is provided in the controller kit.

For conceptual information about arrays, logical drives, and fault-tolerance methods, refer to "Drive Arrays and Fault-Tolerance Methods (on page 53)."

Comparing the Utilities

NOTE: In both tables, a *y* in the appropriate column indicates that the feature or procedure is supported, while an *n* indicates that the feature or procedure is not supported.

Supported Features	ACU	ORCA
Uses a graphical interface	y	n
Available in languages other than English	y	n
Executable at any time	y	n
Available on CD	y	n
Uses a wizard to suggest the optimum configuration for an unconfigured controller	y	n
Describes configuration errors	y	n

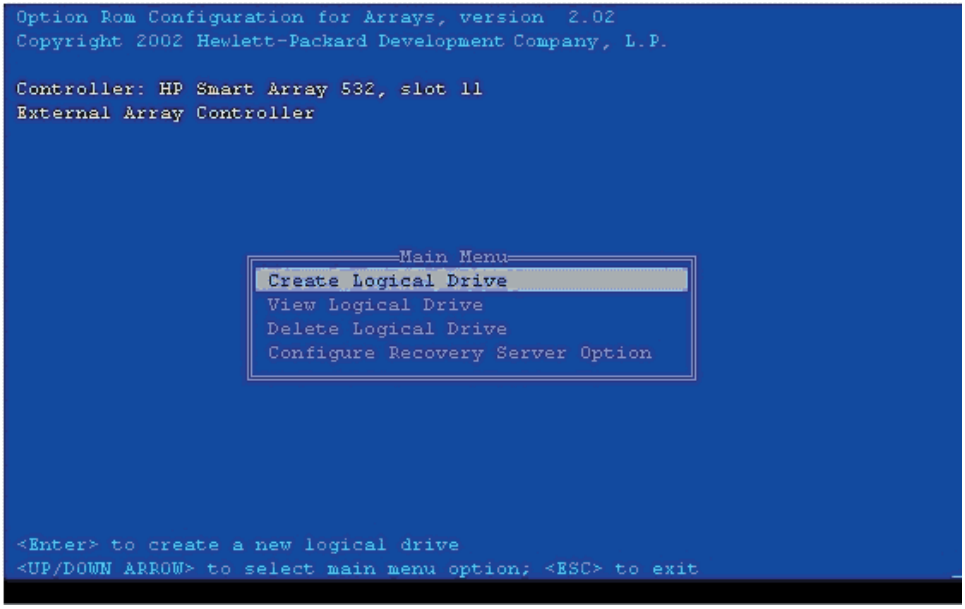
Supported Procedures	ACU	ORCA
Creation and deletion of arrays and logical drives	y	y
Assignment of RAID level	y	y
Sharing of spare drives among several arrays	y	n
Assignment of multiple spare drives per array	y	n
Setting of stripe size	y	n
Migration of RAID level or stripe size	y	n
Configuration of controller settings	y	n
Expansion of an array	y	n
Creation of multiple logical drives per array	y	n
Setting of boot controller	n	y

Using ORCA

NOTE: Before you power up the server in step 1, read through the instructions for step 2 to determine which procedure you must follow to start ORCA. The ORCA prompt persists for only a few seconds, and if you do not start ORCA during this time, you must restart the server to obtain the ORCA prompt again.

1. Power up the server. POST runs, and any array controllers that are in the system are initialized one at a time.
2. Use the appropriate procedure to start ORCA:
   - If you are accessing the server remotely using Telnet or HyperTerminal on a Microsoft® Windows® 2000 or Windows NT® 4.0 system, press the **Esc + 8** keys when the Smart Array banner appears on the remote console.
   - If you are configuring the boot logical drive on a cell-based system, execute a `search all` command at the EFI prompt. When the ORCA prompt appears, press the **F8** key.
   - On all other systems, POST halts for several seconds during each controller initialization process while an ORCA prompt message appears. When you see the prompt, press the **F8** key.

The ORCA main menu appears, enabling you to create, view, or delete a logical drive.



To create a logical drive using ORCA:

1. Select **Create Logical Drive.**

   The screen displays a list of all available (unconfigured) physical drives and the valid RAID options for the system.

2. Use the **Arrow** keys, **Spacebar,** and **Tab** key to navigate around the screen and set up the logical drive, including an online spare drive if one is required.

   NOTE: You cannot use ORCA to configure one spare drive to be shared among several arrays. Only ACU enables you to configure shared spare drives.

   While configuring the logical drive, one of the settings allows you to use either 4 GB or 8 GB as the maximum boot drive size. Selecting 8 GB allows a larger boot partition for operating systems such as Microsoft® Windows NT® 4.0 that use cylinders, heads, and sectors of a physical drive to determine the drive size. The larger boot drive size also lets you increase the size of the logical drive at some later time. However, logical drive performance is likely to decrease if the larger boot drive size is enabled.

3. Press the **Enter** key to accept the settings.
4. Press the **F8** key to confirm the settings and save the new configuration.

   After several seconds, the **Configuration Saved** screen is displayed.
5. Press the **Enter** key to continue.

You can now create another logical drive by repeating the previous steps.

> **NOTE:** Newly created logical drives are invisible to the operating system. To make the new logical drives available for data storage, format them using the instructions given in the operating system documentation.

When you have finished creating the logical boot drive:

1. Exit ORCA.
2. From the EFI Boot Manager, select **EFI Shell [Built-in].**
3. Enter `reset.`

Using ACU

For detailed information about using ACU, refer to the *HP Array Configuration Utility User Guide.* This document is available on the Documentation CD that is provided in the controller kit.

Installing the Device Drivers

In This Section

Loading the OEM Boot Driver

1. Launch EBSU. For detailed instructions, refer to the *HP Smart Setup Installation Poster for Microsoft Windows* in the HP Integrity Server Essentials Foundation Pack.
2. Select **Load OEM Boot Driver.**
3. At the prompt, select the controller model.
4. When the OEM boot driver has finished loading, exit EBSU.

Installing Drivers for Additional Controllers

IMPORTANT: If configuring a new server, install the operating system before installing the device drivers. For operating system installation instructions, refer to the operating system documentation.

If installing additional Smart Array controllers in the server, install the device drivers for these controllers at the same time. For servers that use a supported Microsoft® Windows® operating system, these drivers are present on the CD or DVD that is provided in the controller kit.

1. Power down the server, and disconnect the power cords.
2. Install the new controller, and connect it to storage devices.
3. Power up the server.

   The operating system recognizes the controller and launches the Found New Hardware wizard.
4. In the Files Needed dialog box, select the option to automatically search for the driver.

5. Insert the CD or DVD.
6. When the driver installation process is complete, click **Finish** to exit the wizard, and then click **Yes** to confirm that you want to reboot the server.
7. Repeat the previous steps for each new controller that is to be installed in the server.

Installing the Management Agents

In This Section

Description of the Insight Management Agents

The HP Insight Management Agents for Windows package consists of several services and agents that are used to monitor and report the health of the server and system components. The process memory use table ("Process Memory Used by Insight Management Agents" on page 30) lists the services and agents that are provided in the package and installed on the system when the package is installed.

For more information about Systems Insight Manager, refer to the HP website (http://www.hp.com/go/hpsim).

System Requirements for Insight Management Agents

Item	Requirement
Operating system	Microsoft® Windows® Server 2003 Enterprise Edition or Datacenter Edition
Browser	Microsoft® Internet Explorer 5.5 or later, Netscape 7.1, or Mozilla 1.4
Device drivers	All of the required HP-specific device drivers, except for the MSA1000 driver (CPQFCAC.SYS), are installed automatically when you install the agents.
Disk space	At least 30 MB, if all agents are installed
Other required items	SNMP

Process Memory Used by Insight Management Agents

This table shows the process memory used by the different Systems Insight Management Agents and services on a system that has the minimum acceptable configuration. The memory requirements for any differently-configured system depend on many factors, such as the number of drives in the array, the capacity and condition of the drives, and the configuration of the logical drives. As an extreme example, the process memory that the HP Insight Storage Agent uses increases by about 50 kB for every storage box that you connect to the system.

Service	Description	Process Memory Requirement, MB
CpqWebMgmt	HP Insight Web Agent	12
CpqNicMgmt	HP Insight NIC Agent	7
CpMgHost	HP Insight Foundation Agent	16
CqMgServ	HP Insight Server Agent	6
CqMgStor	HP Insight Storage Agent	6
CIMNTFY	HP Insight Event Notifier	3
Asrsvc	HP Insight Management Automatic System Recovery Service	4.5
Hpesysvc	HP Insight Management Event Synchronization Service	5.2
Hpevtsvc	HP Insight Management Windows Event Service	5.6
Hpler	HP Insight Management Windows Loopback Event Receiver	7.5
Hplersvc	HP Insight Management Windows Loopback Event Receiver Service	2.4
Hpmpsvc	HP Insight Management Processor Service	5.2
Hpmgtsvc	HP Insight Management Service	3.0
	Total agent memory use	83.4

In addition, the SNMP service that must be present for the agents to operate uses a further 16.0 kB of process memory.

Installing the Agents

1. If SNMP is not installed on the server:
   a. Use the Add/Remove Programs utility in the Control Panel folder to install SNMP from the Microsoft® Windows® distribution CD.
   b. Reboot the server.
2. With the operating system running, insert the Smart Setup CD or DVD into the appropriate drive in the server.
3. Click **Software and Drivers** for the server model.
4. Click **HP Insight Management Agents.**
5. Click **HP Insight Management Agents for Integrity Servers with Windows.**
6. Double-click the executable file. Installation of the agents begins.

Upgrading or Replacing Controller Options

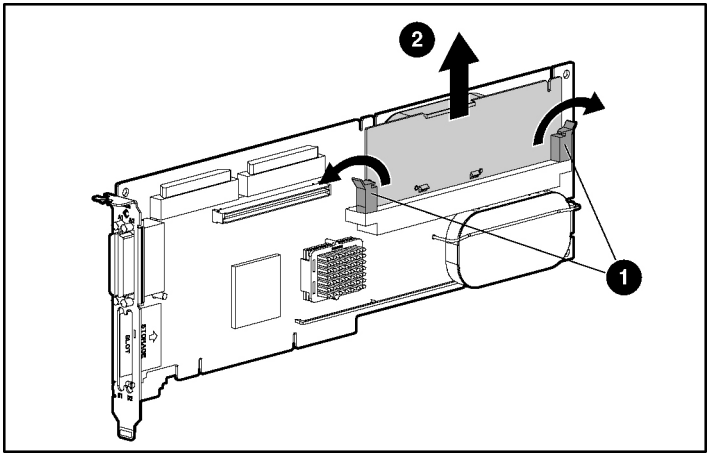
In This Section

Cache Module

The cache module consists of a cache board and a battery pack.

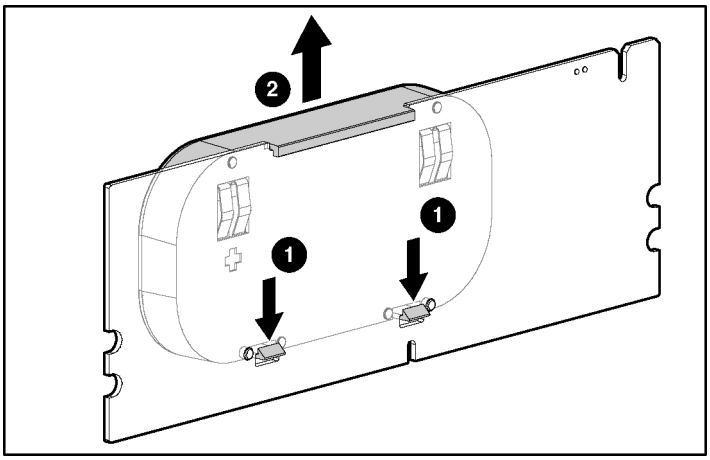
WARNING: There is a risk of explosion, fire, or personal injury if the battery pack is not properly handled. Refer to "Battery Replacement Notice (on page 72)" before installing or removing any item that contains a battery pack.

To remove the Cache Module: Open the DIMM ejector latches on each side of the DIMM connector, and then pull the cache module out of the DIMM slot.



To replace the cache module, reverse this procedure.

To remove the Cache Battery Pack: Press down the retainer tabs and push them through to the other side of the cache board, and then lift the battery pack off the cache board.



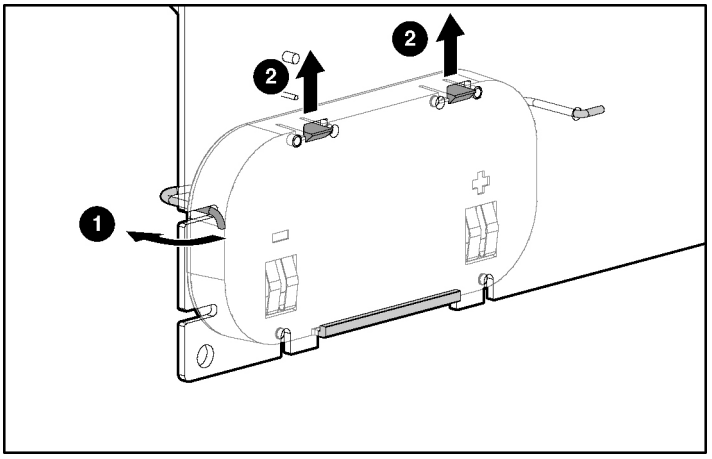
To replace the cache battery pack, reverse this procedure.

Controller Battery Pack

WARNING: There is a risk of explosion, fire, or personal injury if the battery pack is not properly handled. Refer to "Battery Replacement Notice (on page 72)" before installing or removing any item that contains a battery pack.

1. Unhook the wire retainer that holds the battery pack to the controller board.

2. While holding the battery in one hand, pull the plastic retainer tabs upward and push them through to the other side of the controller board.



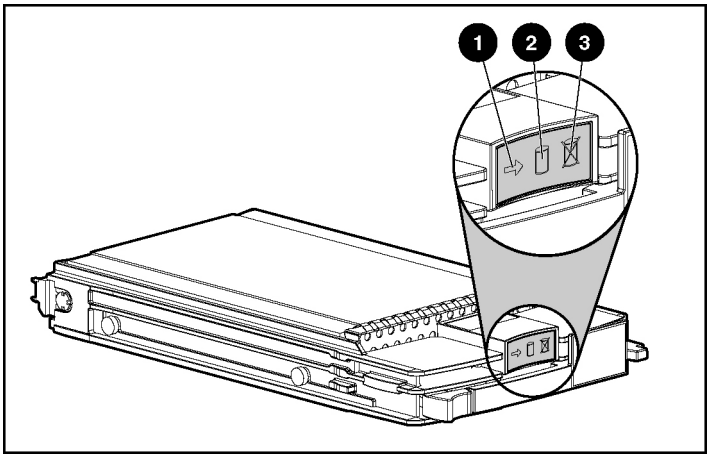
To replace the controller battery pack, reverse this procedure.

Replacing, Moving, or Adding Hard Drives

In This Section

Identifying the Status of a Hard Drive

When a drive is configured as a part of an array and connected to a powered-up controller, the condition of the drive can be determined from the illumination pattern of the hard drive status lights (LEDs). The table ("Hot-Plug SCSI Hard Drive LED Combinations" on page 38) describes the meanings of the different illumination patterns.



Hot-Plug SCSI Hard Drive LED Combinations

Activity LED (1)	Online LED (2)	Fault LED (3)	Interpretation
On, off, or flashing	On or off	Flashing	A predictive failure alert has been received for this drive. Replace the drive as soon as possible.
On, off, or flashing	On	Off	The drive is online and is configured as part of an array. If the array is configured for fault tolerance and all other drives in the array are online, and a predictive failure alert is received or a drive capacity upgrade is in progress, you may replace the drive online.
On or flashing	Flashing	Off	**Do not remove the drive. Removing a drive may terminate the current operation and cause data loss.** The drive is rebuilding or undergoing capacity expansion.
On	Off	Off	**Do not remove the drive.** The drive is being accessed, but (1) it is not configured as part of an array; (2) it is a replacement drive and rebuild has not yet started; or (3) it is spinning up during the POST sequence.
Flashing	Flashing	Flashing	**Do not remove the drive. Removing a drive may cause data loss in non-fault-tolerant configurations.** Either (1) the drive is part of an array being selected by an array configuration utility; (2) Drive Identification has been selected in HP SIM; or (3) drive firmware is being updated.
Off	Off	On	The drive has failed and has been placed offline. You may replace the drive.
Off	Off	Off	Either (1) the drive is not configured as part of an array; (2) the drive is configured as part of an array, but it is a replacement drive that is not being accessed or being rebuilt yet; or (3) the drive is configured as an online spare. If the drive is connected to an array controller, you may replace the drive online.

Recognizing Hard Drive Failure

A steadily glowing Fault LED indicates that that drive has failed. Other means by which hard drive failure is revealed are:

- The amber LED on the front of a storage system illuminates if failed drives are inside. (However, this LED also illuminates when other problems occur, such as when a fan fails, a redundant power supply fails, or the system overheats.)
- A POST message lists failed drives whenever the system is restarted, as long as the controller detects at least one functional drive.
- ACU represents failed drives with a distinctive icon.
- Systems Insight Manager can detect failed drives remotely across a network. (For more information about Systems Insight Manager, refer to the documentation on the Management CD.)
- ADU lists all failed drives.

For additional information about diagnosing hard drive problems, refer to the *HP Servers Troubleshooting Guide.*

CAUTION: Sometimes, a drive that has previously been failed by the controller may seem to be operational after the system is power-cycled or (for a hot-pluggable drive) after the drive has been removed and reinserted. However, continued use of such marginal drives may eventually result in data loss. Replace the marginal drive as soon as possible.

Effects of a Hard Drive Failure

When a hard drive fails, all logical drives that are in the same array are affected. Each logical drive in an array may be using a different fault-tolerance method, so each logical drive can be affected differently.

- RAID 0 configurations cannot tolerate drive failure. If any physical drive in the array fails, all non-fault-tolerant (RAID 0) logical drives in the same array will also fail.

- RAID 1+0 configurations can tolerate multiple drive failures as long as no failed drives are mirrored to one another.
- RAID 5 configurations can tolerate one drive failure.
- RAID ADG configurations can tolerate simultaneous failure of two drives.

Compromised Fault Tolerance

If more hard drives fail than the fault-tolerance method allows, fault tolerance is compromised, and the logical drive fails. In this case, all requests from the operating system are rejected with unrecoverable errors. You are likely to lose data, although it can sometimes be recovered (refer to "Recovering from Compromised Fault Tolerance" on page 40).

One example of a situation in which compromised fault tolerance may occur is when a drive in an array fails while another drive in the array is being rebuilt. If the array has no online spare, any logical drives in this array that are configured with RAID 5 fault tolerance will fail.

Compromised fault tolerance can also be caused by non-drive problems, such as a faulty cable or temporary power loss to a storage system. In such cases, you do not need to replace the physical drives. However, you may still have lost data, especially if the system was busy at the time that the problem occurred.

Recovering from Compromised Fault Tolerance

If fault tolerance is compromised, inserting replacement drives does not improve the condition of the logical volume. Instead, if the screen displays unrecoverable error messages, perform the following procedure to recover data:

1. Power down the entire system, and then power it back up. In some cases, a marginal drive will work again for long enough to enable you to make copies of important files.

   If a 1779 POST message is displayed, press the **F2** key to re-enable the logical volumes. Remember that data loss has probably occurred and any data on the logical volume is suspect.

2. Make copies of important data, if possible.

3. Replace any failed drives.
4. After you have replaced the failed drives, fault tolerance may again be compromised. If so, cycle the power again. If the 1779 POST message is displayed:
   a. Press the **F2** key to re-enable the logical drives.
   b. Recreate the partitions.
   c. Restore all data from backup.

To minimize the risk of data loss that is caused by compromised fault tolerance, make frequent backups of all logical volumes.

Replacing Hard Drives

The most common reason for replacing a hard drive is that it has failed. However, another reason is to gradually increase the storage capacity of the entire system ("Upgrading Hard Drive Capacity" on page 44).

If you insert a hot-pluggable drive into a drive bay while the system power is on, all disk activity in the array pauses while the new drive is spinning up. This spin-up process usually lasts for approximately 20 seconds. When the drive has achieved its normal spin rate, data recovery to the replacement drive begins automatically (as indicated by the blinking Online LED on the replacement drive) if the array is in a fault-tolerant configuration.

If you replace a drive belonging to a fault-tolerant configuration while the system power is off, a POST message is displayed when the system is next powered up. This message prompts you to press the **F1** key to start automatic data recovery. If you do not enable automatic data recovery, the logical volume remains in a ready-to-recover condition and the same POST message is displayed whenever the system is restarted.

Factors to Consider Before Replacing Hard Drives

- In systems that use external data storage, be sure that the server is the first unit to be powered down and the last to be powered back up. Taking this precaution ensures that the system does not erroneously mark the drives as failed when the server is powered up.

- If you set the SCSI ID jumpers manually:
  - Check the ID value of the removed drive to be sure that it corresponds to the ID of the drive marked as failed.
  - Set the same ID value on the replacement drive to prevent SCSI ID conflicts.

Before replacing a degraded drive:

- Open Systems Insight Manager and inspect the Error Counter window for each physical drive in the same array to confirm that no other drives have any errors. (For details, refer to the Systems Insight Manager documentation on the Management CD.)
- Be sure that the array has a current, valid backup.
- Use replacement drives that have a capacity at least as great as that of the smallest drive in the array. The controller immediately fails drives that have insufficient capacity.

To minimize the likelihood of fatal system errors, take these precautions when removing failed drives:

- Do not remove a degraded drive if any other drive in the array is offline (the Online LED is off). In this situation, no other drive in the array can be removed without data loss.

  Exceptions:

  - When RAID 1+0 is used, drives are mirrored in pairs. Several drives can be in a failed condition simultaneously (and they can all be replaced simultaneously) without data loss, as long as no two failed drives belong to the same mirrored pair.
  - When RAID ADG is used, two drives can fail simultaneously (and be replaced simultaneously) without data loss.
  - If the offline drive is a spare, the degraded drive can be replaced.
- Do not remove a second drive from an array until the first failed or missing drive has been replaced **and** the rebuild process is complete. (The rebuild is complete when the Online LED on the front of the drive stops blinking.)

  These cases are the exceptions:

- In RAID ADG configurations, any two drives in the array can be replaced simultaneously.
- In RAID 1+0 configurations, any drives that are not mirrored to other removed or failed drives can be simultaneously replaced offline without data loss.

Automatic Data Recovery (Rebuild)

When you replace a hard drive in an array, the controller uses the fault-tolerance information on the remaining drives in the array to reconstruct the missing data (the data that was originally on the replaced drive) and write it to the replacement drive. This process is called automatic data recovery, or rebuild. If fault tolerance is compromised, this data cannot be reconstructed and is likely to be permanently lost.

If another drive in the array fails while fault tolerance is unavailable during rebuild, a fatal system error may occur, and all data on the array is then lost. In exceptional cases, however, failure of another drive need not lead to a fatal system error. These exceptions include:

- Failure after activation of a spare drive
- Failure of a drive that is not mirrored to any other failed drives (in a RAID 1+0 configuration)
- Failure of a second drive in a RAID ADG configuration

Time Required for a Rebuild

The time required for a rebuild varies considerably, depending on several factors:

- The priority that the rebuild is given over normal I/O operations (you can change the priority setting by using ACU)
- The amount of I/O activity during the rebuild operation
- The rotational speed of the hard drives
- The availability of drive cache
- The brand, model, and age of the drives
- The amount of unused capacity on the drives

- The number of drives in the array (for RAID 5 and RAID ADG)

Allow approximately 15 minutes per gigabyte for the rebuild process to be completed. This figure is conservative, and newer drive models usually require less time to rebuild.

System performance is affected during the rebuild, and the system is unprotected against further drive failure until the rebuild has finished. Therefore, replace drives during periods of low activity when possible.

CAUTION: If the Online LED of the replacement drive stops blinking and the amber Fault LED glows, or if other drive LEDs in the array go out, the replacement drive has failed and is producing unrecoverable disk errors. Remove and replace the failed replacement drive.

When automatic data recovery has finished, the Online LED of the replacement drive stops blinking and begins to glow steadily.

Failure of Another Drive During Rebuild

If a non-correctable read error occurs on another physical drive in the array during the rebuild process, the Online LED of the replacement drive stops blinking and the rebuild abnormally terminates.

If this situation occurs, reboot the server. The system may temporarily become operational long enough to allow recovery of unsaved data. In any case, locate the faulty drive, replace it, and restore data from backup.

Upgrading Hard Drive Capacity

You can increase the storage capacity on a system even if there are no available drive bays by swapping drives one at a time for higher capacity drives. This method is viable as long as a fault-tolerance method is running.

CAUTION: Because it can take up to 15 minutes per gigabyte to rebuild the data in the new configuration, the system is unprotected against drive failure for many hours while a given drive is upgraded. Perform drive capacity upgrades only during periods of minimal system activity.

To upgrade hard drive capacity:

1. Back up all data.
2. Replace any drive. The data on the new drive is recreated from redundant information on the remaining drives.

CAUTION: Do not replace any other drive until data rebuild on this drive is complete.

3. When data on the new drive has been rebuilt (the Activity LED turns off), repeat the previous step for the other drives in the array, one at a time.

When you have replaced all drives, you can use the extra capacity to either create new logical drives or extend existing logical drives. For more information about these procedures, refer to the *HP Array Configuration Utility User Guide*.

Moving Drives and Arrays

You can move drives to other ID positions on the same array controller. You can also move a complete array from one controller to another, even if the controllers are on different servers.

Before you move drives, the following conditions must be met:

- If moving the drives to a different server, the new server must have enough empty bays to accommodate all the drives simultaneously.
- The move will not result in more than 14 physical drives per controller channel.
- No controller will be configured with more than 32 logical volumes.
- The array has no failed or missing drives.
- The array is in its original configuration.

- The controller is not reading from or writing to any of the spare drives in the array.
- The controller is not running capacity expansion, capacity extension, or RAID or stripe size migration.
- The controller is using the latest firmware version (recommended).

If you want to move an array to another controller, you must also consider the following additional limitations:

- All drives in the array must be moved at the same time.
- In most cases, a moved array (and the logical drives that it contains) can still undergo array capacity expansion, logical drive capacity extension, or migration of RAID level or stripe size. An exception occurs when the array meets **all** of these conditions:
  - It was originally created on a SMART-2/P, SMART-2DH, SA-3200, SA-3100ES, SA-4200, SA-4250ES, or SA-530x controller.
  - It is moved to a controller that does not have a battery-backed cache.
  - It has less than 4 MB of unused capacity.
- If a controller contains a RAID ADG logical volume, none of the arrays on the controller can be moved **directly** to a controller that does not support RAID ADG. The arrays can be moved **indirectly**, as described by the instructions in this section.

When all the conditions have been met:

1. Back up all data before removing any drives or changing configuration. This step is **required** if you are moving data-containing drives from a controller that does not have a battery-backed cache.
2. Power down the system.
3. If you are moving an array from a controller that contains a RAID ADG logical volume to a controller that does not support RAID ADG:
   a. Remove or disconnect the drives that contain the RAID ADG logical volume.
   b. Reboot the server.

c. Open ACU and navigate to the controller that contained the RAID ADG volume.

   ACU displays the missing RAID ADG volume using a different icon to indicate that the volume is unavailable.

d. Delete the RAID ADG volume.

e. Accept the configuration change, and then close ACU.

f. Power down the system.

4. Move the drives.
5. Power up the system. If a 1724 POST message is displayed, drive positions were changed successfully and the configuration was updated.

   If a 1785 (Not Configured) POST message is displayed:

   a. Power down the system immediately to prevent data loss.

   b. Return the drives to their original locations.

   c. Restore the data from backup, if necessary.

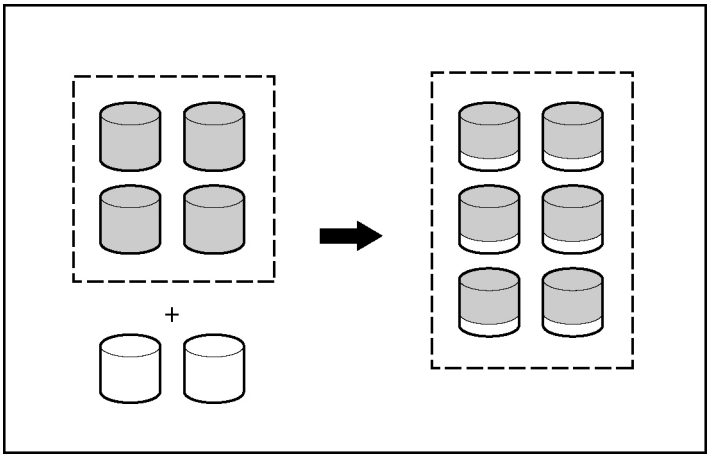
6. Check the new drive configuration by running ORCA or ACU ("Configuring an Array" on page 21).

Adding Drives

You can add hard drives to a system at any time, as long as you do not exceed the maximum number of drives that the controller supports. You can then either build a new array from the added drives or use the extra storage capacity to expand the capacity of an existing array.

To perform an array capacity expansion, use ACU. If the system is using hot-pluggable drives, you can expand array capacity without shutting down the operating system (that is, with the server online) if ACU is running in the same environment as the normal server applications. (For more information, refer to the *HP Array Configuration Utility User Guide*.)

The expansion process is illustrated in the following figure, in which the original array (containing data) is shown with a dashed border and the newly added drives (containing no data) are shown unshaded. The array controller adds the new drives to the array and redistributes the original logical drives over the enlarged array one logical drive at a time. This process liberates some storage capacity on each of the physical drives in the array. During this procedure, the logical drives each keep the same fault-tolerance method in the enlarged array that they had in the smaller array.



When the expansion process has finished, you can use the liberated storage capacity on the enlarged array to create new logical drives. Alternatively, you can enlarge one of the original logical drives. This latter process is called **logical drive capacity extension** and is also carried out using ACU.

Diagnosing Array Problems

In This Section

Diagnostic Tools

Several diagnostic tools provide feedback about problems with arrays. The most important are:

- **ADU**

  This utility can be downloaded from the HP website (http://www.hp.com/support). The meanings of the various ADU error messages are provided in the *HP Servers Troubleshooting Guide.*

- **POST messages**

  Smart Array controllers produce diagnostic error messages at reboot. Many of these POST messages are self-explanatory and suggest corrective actions. For more information about POST messages, refer to the *HP Servers Troubleshooting Guide.*

- **Offline Diagnostics and Utilities**

  This set of tools for Integrity servers is available on the CD or DVD that is supplied in the controller kit. To use one of these tools, insert the CD or DVD into the appropriate server drive and follow the on-screen prompts and instructions.

Probability of Logical Drive Failure

In This Section

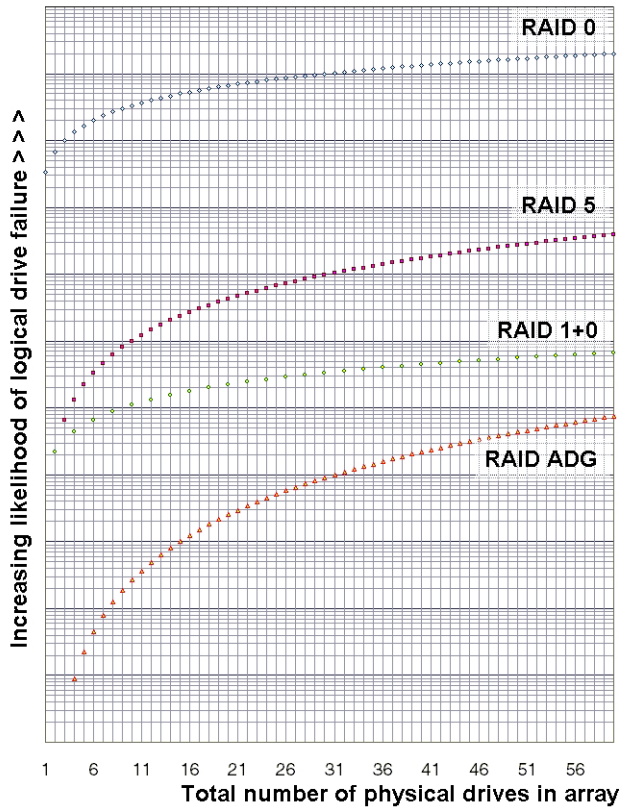
Factors Involved in Logical Drive Failure

The probability that a logical drive will fail depends on the RAID level setting and on the number and type of physical drives in the array. If the logical drive does not have an online spare, the following results apply:

- A RAID 0 logical drive fails if only one physical drive fails.
- A RAID 1+0 logical drive fails if any two failed physical drives are mirrored to each other.
  - The **maximum** number of physical drives that can fail **without** causing failure of the logical drive is *n*/2, where *n* is the number of hard drives in the array. In practice, a logical drive usually fails before this maximum is reached. As the number of failed physical drives increases, it becomes increasingly likely that the newly failed drive is mirrored to a previously failed drive.
  - The **minimum** number of physical drive failures that can cause the logical drive to fail is two. This situation occurs when the two failed drives are mirrored to each other. As the total number of drives in the array increases, the probability that the only two failed drives in an array are mirrored to each other decreases.
- A RAID 5 logical drive fails if two physical drives fail.
- A RAID ADG logical drive fails when three physical drives fail.

At any given RAID level, the probability of logical drive failure increases as the number of physical drives in the logical drive increases. This is illustrated more quantitatively in the graph ("Probability of Logical Drive Failure vs. Number of Drives in Array" on page 52). The data for this graph is calculated from the MTBF value for a typical physical drive, assuming that no online spares are present. If an online spare is added to any of the fault-tolerant RAID configurations, the probability of logical drive failure is further decreased.

Probability of Logical Drive Failure vs. Number of Drives in Array



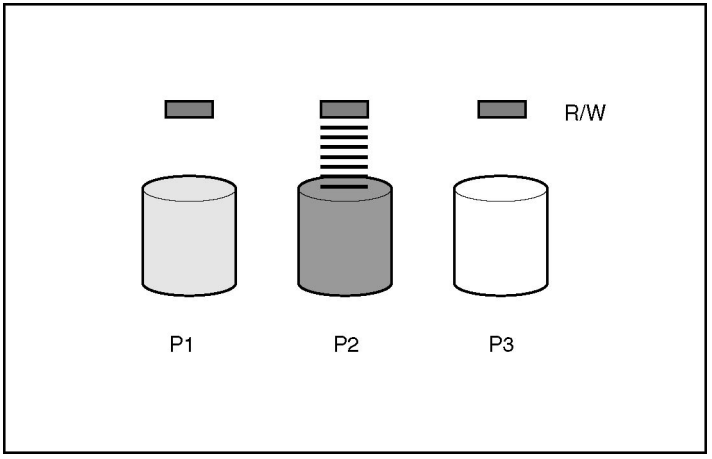
Drive Arrays and Fault-Tolerance Methods

In This Section

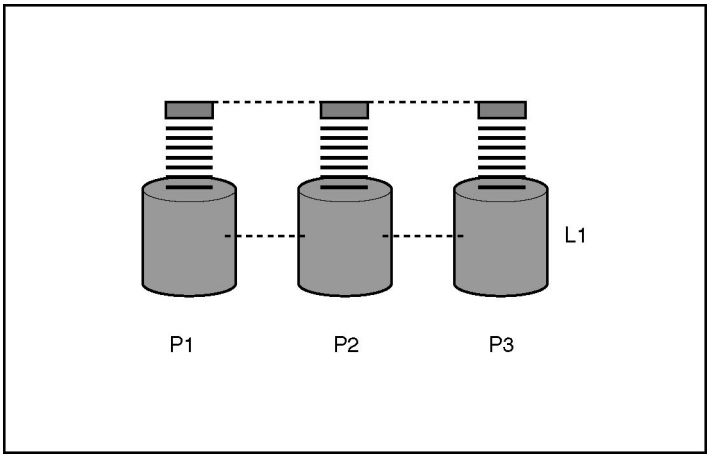
Drive Arrays

The capacity and performance of a single physical (hard) drive is adequate for home users. However, business users demand higher storage capacities, higher data transfer rates, and greater protection against data loss when drives fail.

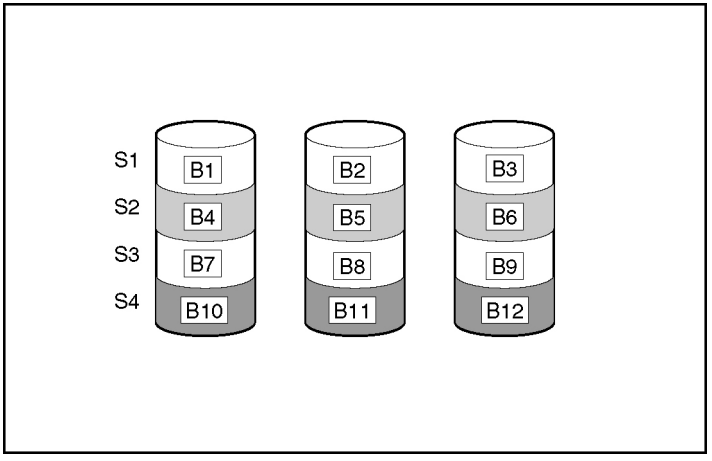
Connecting extra physical drives (P*n* in the figure) to a system increases the total storage capacity but has no effect on the efficiency of read/write (R/W) operations. Data can still be transferred to only one physical drive at a time.



With an array controller installed in the system, the capacity of several physical drives can be combined into one or more virtual units called **logical drives** (also called **logical volumes** and denoted by L*n* in the figures in this section). Then, the read/write heads of all the constituent physical drives are active simultaneously, reducing the total time required for data transfer.



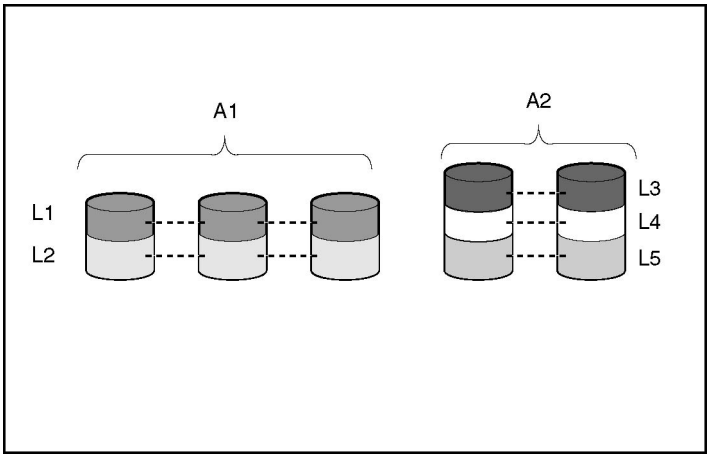
Because the read/write heads are active simultaneously, the same amount of data is written to each drive during any given time interval. Each unit of data is called a **block** (denoted by B*n* in the figure), and adjacent blocks form a set of data **stripes** (S*n*) across all the physical drives that comprise the logical drive.



For data in the logical drive to be readable, the data block sequence must be the same in every stripe. This sequencing process is performed by the array controller, which sends the data blocks to the drive write heads in the correct order.

A natural consequence of the striping process is that each physical drive in a given logical drive will contain the same amount of data. If one physical drive has a larger capacity than other physical drives in the same logical drive, the extra capacity is wasted because it cannot be used by the logical drive.

The group of physical drives containing the logical drive is called a **drive array,** or just **array** (denoted by A*n* in the figure). Because all the physical drives in an array are commonly configured into just one logical drive, the term array is often used as a synonym for logical drive. However, an array can contain several logical drives, each of a different size.



Each logical drive in an array is distributed across all of the physical drives within the array. A logical drive can also extend across more than one port on the same controller, but it cannot extend across more than one controller.

Drive failure, although rare, is potentially catastrophic. For arrays that are configured as shown in the previous figure, failure of any physical drive in the array causes every logical drive in the array to suffer irretrievable data loss. To protect against data loss due to physical drive failure, logical drives are configured with **fault tolerance** ("Fault-Tolerance Methods" on page 56).

For any configuration except RAID 0, further protection against data loss can be achieved by assigning a drive as an **online spare** (or **hot spare**). This drive contains no data and is connected to the same controller as the array. When any other physical drive in the array fails, the controller automatically rebuilds information that was originally on the failed drive to the online spare. The system is thus restored to full RAID-level data protection, although it now no longer has an online spare. (However, in the unlikely event that another drive in the array fails while data is being rewritten to the spare, the logical drive will still fail.)

When you configure an online spare, it is automatically assigned to all logical drives in the same array. Additionally, you do not need to assign a separate online spare to each array. Instead, you can configure one hard drive to be the online spare for several arrays if the arrays are all on the same controller.

Fault-Tolerance Methods

Several fault-tolerance methods exist. Those most often used with Smart Array controllers are hardware-based RAID methods.

Two alternative fault-tolerance methods that are sometimes used are also described ("Alternative Fault-Tolerance Methods" on page 62). However, hardware-based RAID methods provide a much more robust and controlled fault-tolerance environment, so these alternative methods are seldom used.

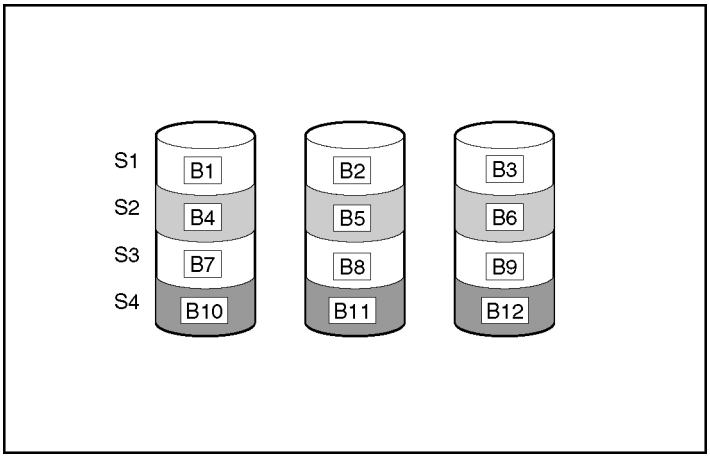
Hardware-Based Fault-Tolerance Methods

The hardware-based methods that are recommended for use with Smart Array controllers are:

- RAID 0—Data Striping only (no fault tolerance)
- RAID 1+0—Drive Mirroring
- RAID 5—Distributed Data Guarding
- RAID ADG—Advanced Data Guarding

RAID 0—No Fault Tolerance

A RAID 0 configuration provides data striping, but there is no protection against data loss when a drive fails. However, it is useful for rapid storage of large amounts of noncritical data (for printing or image editing, for example) or when cost is the most important consideration.



Advantages:

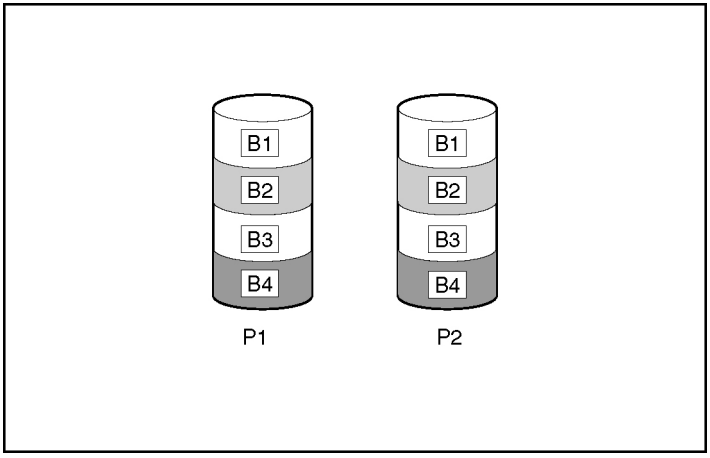
- Has the highest write performance of all RAID methods.
- Has the lowest cost per unit of stored data of all RAID methods.
- All drive capacity is used to store data (none is needed for fault tolerance).

Disadvantages:

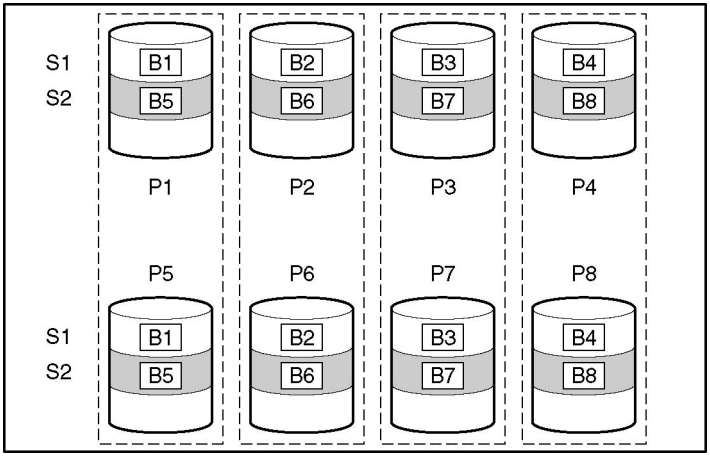
- All data on the logical drive is lost if a physical drive fails.
- Cannot use an online spare.
- Can only preserve data by backing it up to external drives.

RAID 1+0—Drive Mirroring

In a RAID 1+0 configuration, data is duplicated to a second drive.



When the array has more than two physical drives, drives are mirrored in pairs.



In each mirrored pair, the physical drive that is not busy answering other requests answers any read requests that are sent to the array. (This behavior is called **load balancing.**) If a physical drive fails, the remaining drive in the mirrored pair can still provide all the necessary data. Several drives in the array can fail without incurring data loss, as long as no two failed drives belong to the same mirrored pair.

This fault-tolerance method is useful when high performance and data protection are more important than the cost of physical drives.

NOTE: When there are only two physical drives in the array, this fault-tolerance method is often referred to as RAID 1.

Advantages:

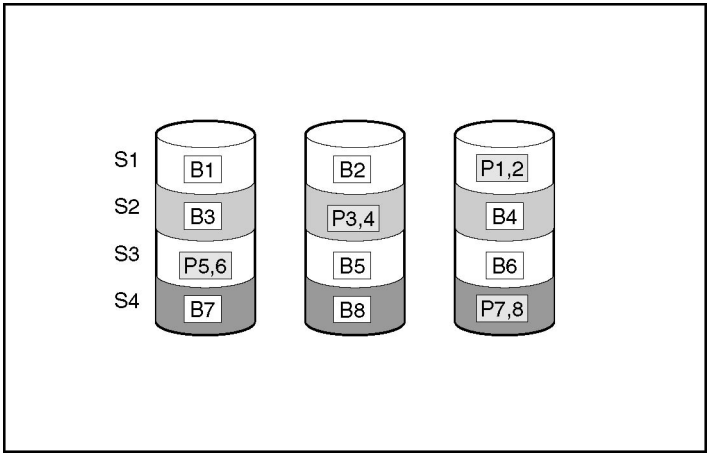
- Has the highest read performance of any fault-tolerant configuration.
- No data is lost when a drive fails, as long as no failed drive is mirrored to another failed drive (up to half of the physical drives in the array can fail).

Disadvantages:

- This method is expensive (many drives are needed for fault tolerance).
- Only half of the total drive capacity is usable for data storage.

RAID 5—Distributed Data Guarding

In a RAID 5 configuration, data protection is provided by **parity data** (denoted by P*x,y* in the figure). This parity data is calculated stripe by stripe from the user data that is written to all other blocks within that stripe. The blocks of parity data are distributed evenly over every physical drive within the logical drive.



When a physical drive fails, data that was on the failed drive can be calculated from the remaining parity data and user data on the other drives in the array. This recovered data is usually written to an online spare in a process called a **rebuild.**

This configuration is useful when cost, performance, and data availability are equally important.

Advantages:

- Has high read performance.
- Data is not lost if one physical drive fails.
- More drive capacity is usable than with RAID 1+0—parity information requires only the storage space equivalent to one physical drive.

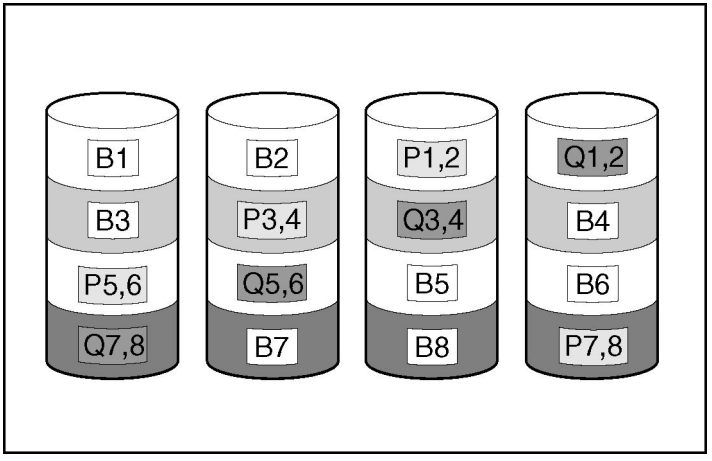
Disadvantages:

- Has relatively low write performance.
- Data is lost if a second drive fails before data from the first failed drive is rebuilt.

RAID ADG—Advanced Data Guarding

NOTE: Not all controllers support RAID ADG.

RAID ADG, like RAID 5, generates and stores parity information to protect against data loss caused by drive failure. With RAID ADG, however, two different sets of parity data are used (denoted by P*x,y* and Q*x,y* in the figure), allowing data to still be preserved if two drives fail. Each set of parity data uses a capacity equivalent to that of one of the constituent drives.



This method is most useful when data loss is unacceptable but cost is also an important factor. The probability that data loss will occur when an array is configured with RAID ADG is less than it would be if it were configured with RAID 5.

Advantages:

- Has a high read performance.
- Allows high data availability—any two drives can fail without loss of critical data.
- More drive capacity is usable than with RAID 1+0—parity information requires only the storage space equivalent to two physical drives.

Disadvantages:

The main disadvantage of RAID ADG is a relatively low write-performance (lower than RAID 5), because of the need for two sets of parity data.

Comparing the Hardware-Based RAID Methods

NOTE: Not all controllers support RAID ADG.

Item	RAID 0	RAID 1+0	RAID 5	RAID ADG
Alternative name	Striping (no fault tolerance)	Mirroring	Distributed Data Guarding	Advanced Data Guarding
Formula for number of drives usable for data (*n* = total number of drives in array)	*n*	*n*/2	*n*-1	*n*-2
Fraction of drive space usable*	100%	50%	67% to 93%	50% to 96%
Minimum number of physical drives	1	2	3	4
Tolerates failure of one physical drive	No	Yes	Yes	Yes
Tolerates simultaneous failure of more than one physical drive	No	Only if no two failed drives are in the same mirrored pair	No	Yes
Read performance	High	High	High	High

Item	RAID 0	RAID 1+0	RAID 5	RAID ADG
Write performance	High	Medium	Low	Low
Relative cost	Low	High	Medium	Medium

*Values for the fraction of drive space usable are calculated with these assumptions: (1) all physical drives in the array have the same capacity; (2) online spares are not used; (3) no more than 14 physical drives are used per array for RAID 5; and (4) no more than 56 drives are used with RAID ADG.

Selecting a RAID Method

NOTE: Not all controllers support RAID ADG.

Most Important Criterion	Also Important	Suggested RAID Level
Fault tolerance	Cost effectiveness	RAID ADG
	I/O performance	RAID 1+0
Cost effectiveness	Fault tolerance	RAID ADG
	I/O performance	RAID 5 (RAID 0 if fault tolerance is not required)
I/O performance	Cost effectiveness	RAID 5 (RAID 0 if fault tolerance is not required)
	Fault tolerance	RAID 1+0

Alternative Fault-Tolerance Methods

Your operating system may also support software-based RAID or controller duplexing.

- **Software-based RAID** resembles hardware-based RAID, except that the operating system works with logical drives as if they were physical drives. To protect against data loss caused by physical drive failure, each logical drive must be in a different array from the others.
- **Controller duplexing** uses two identical controllers with independent, identical sets of drives containing identical data. In the unlikely event of a controller failure, the remaining controller and drives will service all requests.

Neither of these alternative fault-tolerance methods supports online spares or automatic data recovery, nor do they support auto-reliability monitoring or interim data recovery.

If you decide to use one of these alternative methods, configure your arrays with RAID 0 for maximum storage capacity and refer to your operating system documentation for further implementation details.

Electrostatic Discharge

In This Section

Preventing Electrostatic Discharge

To prevent damaging the system, be aware of the precautions you need to follow when setting up the system or handling parts. A discharge of static electricity from a finger or other conductor may damage system boards or other static-sensitive devices. This type of damage may reduce the life expectancy of the device.

To prevent electrostatic damage:

- Avoid hand contact by transporting and storing products in static-safe containers.
- Keep electrostatic-sensitive parts in their containers until they arrive at static-free workstations.
- Place parts on a grounded surface before removing them from their containers.
- Avoid touching pins, leads, or circuitry.
- Always be properly grounded when touching a static-sensitive component or assembly.

Grounding Methods to Prevent Electrostatic Discharge

Several methods are used for grounding. Use one or more of the following methods when handling or installing electrostatic-sensitive parts:

- Use a wrist strap connected by a ground cord to a grounded workstation or computer chassis. Wrist straps are flexible straps with a minimum of 1 megohm ±10 percent resistance in the ground cords. To provide proper ground, wear the strap snug against the skin.
- Use heel straps, toe straps, or boot straps at standing workstations. Wear the straps on both feet when standing on conductive floors or dissipating floor mats.
- Use conductive field service tools.
- Use a portable field service kit with a folding static-dissipating work mat.

If you do not have any of the suggested equipment for proper grounding, have an authorized reseller install the part.

For more information on static electricity or assistance with product installation, contact your authorized reseller.

Regulatory Compliance Notices

In This Section

Federal Communications Commission Notice

Part 15 of the Federal Communications Commission (FCC) Rules and Regulations has established Radio Frequency (RF) emission limits to provide an interference-free radio frequency spectrum. Many electronic devices, including computers, generate RF energy incidental to their intended function and are, therefore, covered by these rules. These rules place computers and related peripheral devices into two classes, A and B, depending upon their intended installation. Class A devices are those that may reasonably be expected to be installed in a business or commercial environment. Class B devices are those that may reasonably be expected to be installed in a residential environment (for example, personal computers). The FCC requires devices in both classes to bear a label indicating the interference potential of the device as well as additional operating instructions for the user.

FCC Rating Label

The FCC rating label on the device shows the classification (A or B) of the equipment. Class B devices have an FCC logo or ID on the label. Class A devices do not have an FCC logo or ID on the label. After you determine the class of the device, refer to the corresponding statement.

Class A Equipment

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at personal expense.

Class B Equipment

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit that is different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

Declaration of Conformity for Products Marked with the FCC Logo, United States Only

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

For questions regarding this product, contact us by mail or telephone:

- Hewlett-Packard Company
  P. O. Box 692000, Mail Stop 530113
  Houston, Texas 77269-2000
- 1-800-652-6672 (For continuous quality improvement, calls may be recorded or monitored.)

For questions regarding this FCC declaration, contact us by mail or telephone:

- Hewlett-Packard Company
  P. O. Box 692000, Mail Stop 510101
  Houston, Texas 77269-2000
- 1-281-514-3333

To identify this product, refer to the part, series, or model number found on the product.

Modifications

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Hewlett-Packard Company may void the user's authority to operate the equipment.

Cables

Connections to this device must be made with shielded cables with metallic RFI/EMI connector hoods in order to maintain compliance with FCC Rules and Regulations.

Canadian Notice (Avis Canadien)

Class A Equipment

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B Equipment

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

European Union Notice

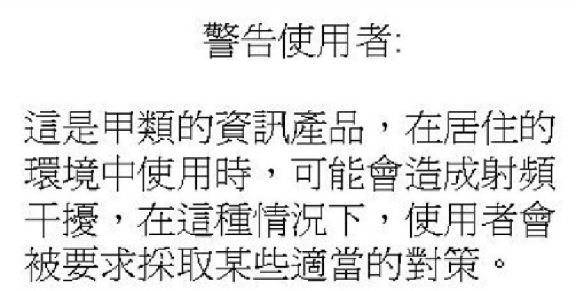
CE

Products bearing the CE marking comply with the EMC Directive (89/336/EEC) and the Low Voltage Directive (73/23/EEC) issued by the Commission of the European Community and, if this product has telecommunication functionality, the R&TTE Directive (1999/5/EC).

Compliance with these directives implies conformity to the following European Norms (in parentheses are the equivalent international standards and regulations):

- EN 55022 (CISPR 22)—Electromagnetic Interference
- EN55024 (IEC61000-4-2, 3, 4, 5, 6, 8, 11)—Electromagnetic Immunity
- EN 60950 (IEC60950)—Product Safety

BSMI Notice



Japanese Notice

ご使用になっている装置にVCCIマークが付いていましたら、次の説明文をお読み下さい。

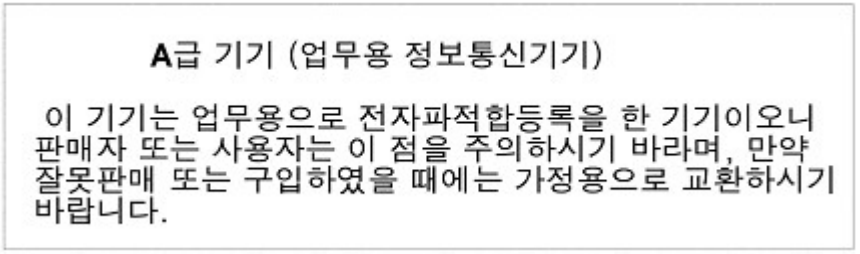
この装置は、情報処理装置等電波障害自主規制協議会（VCCI）の基準に基づくクラスB情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。
取扱説明書に従って正しい取り扱いをして下さい。

VCCIマークが付いていない場合には、次の点にご注意下さい。

この装置は、情報処理装置等電波障害自主規制協議会（VCCI）の基準に基づくクラスA情報技術装置です　この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。

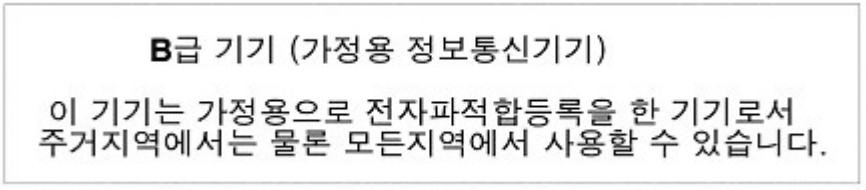
Korean Class A Notice

Class A Equipment



Korean Class B Notice

Class B Equipment



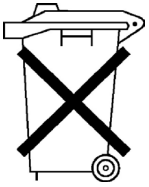
Battery Replacement Notice

This component uses a nickel metal hydride (NiMH) battery pack.

WARNING: There is a risk of explosion, fire, or personal injury if a battery pack is mishandled. To reduce this risk:

- **Do not attempt to recharge the batteries if they are disconnected from the controller.**
- **Do not expose the battery pack to water, or to temperatures higher than 60°C (140°F).**
- **Do not abuse, disassemble, crush, or puncture the battery pack.**
- **Do not short the external contacts.**
- **Replace the battery pack only with the designated HP spare.**

Battery disposal should comply with local regulations.



Batteries, battery packs, and accumulators should not be disposed of together with the general household waste. To forward them to recycling or proper disposal, use the public collection system or return them by established parts return methods to HP, an authorized HP Partner, or one of their agents.

For more information about battery replacement or proper disposal, contact an authorized reseller or an authorized service provider.

Acronyms and Abbreviations

ACU

Array Configuration Utility

ADG

Advanced Data Guarding

ADU

Array Diagnostics Utility

DIMM

dual inline memory module

EBSU

EFI-based setup utility

EFI

extensible firmware interface

ESD

electrostatic discharge

EULA

end user license agreement

LED

light-emitting diode

MSA

Modular Smart Array

MTBF

mean time between failures

OEM

original equipment manufacturer

ORCA

Option ROM Configuration for Arrays

PCI-X

peripheral component interconnect extended

POST

Power-On Self-Test

RAID

redundant array of inexpensive (or independent) disks

RBSU

ROM-Based Setup Utility

SA

Smart Array

SIM

Systems Insight Manager

SNMP

Simple Network Management Protocol

VHDCI

very high density cable interconnect

Index